



NATIONAL RECONNAISSANCE OFFICE

# Applying Data to Improve Schedule Analysis

**NASA Cost and Schedule Symposium**

**Ivan Bembers, Siemone Cerase, Tony Claridge, Michelle Jones**

**April 26-28 2022**



SUPRA ET ULTRA



# Abstract

---

Submitted by: Ivan Bembers, Siemone Cerase, Tony Claridge, Michelle Jones

Topic: Using data to improve schedule analysis

The National Reconnaissance Office analyzes monthly cost and schedule data for acquisition programs and maintains a central repository of historical information. The Cost and Acquisition Assessment Group has been conducting research on program performance to improve schedule analysis by better understanding schedule variance, program recovery and milestone delivery.

This briefing will share results of completed studies:

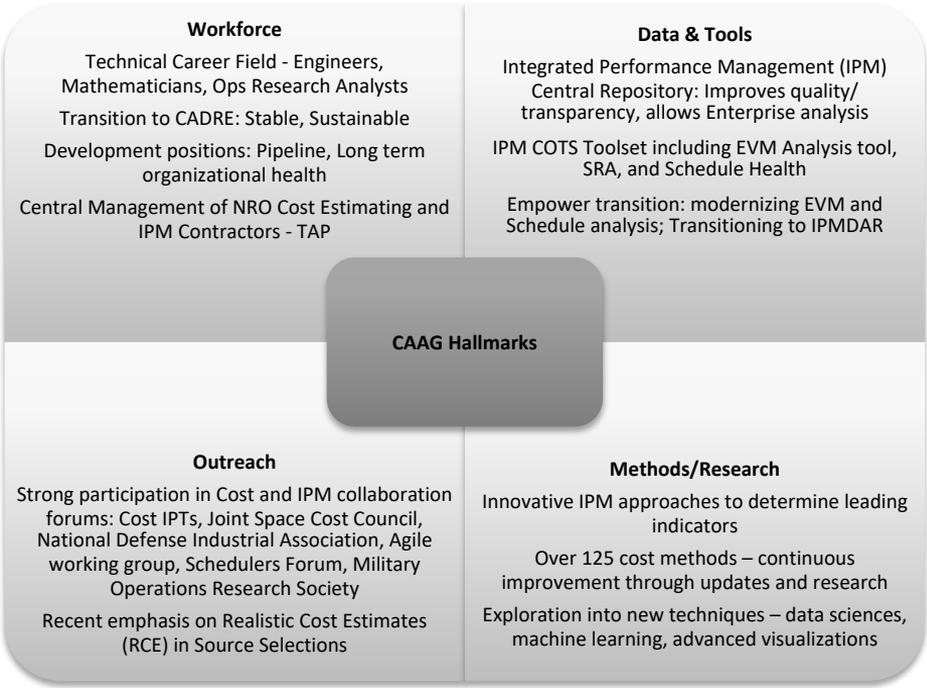
- Data driven duration uncertainty parameters to improve schedule risk assessment
- Schedule Execution Metric Thresholds for data driven predictive analysis
- Benchmarking with a Schedule Estimating Relationship
- Conclusions from Phase 1 Schedule Margin Study

This briefing also includes emerging topics:

- Approach to Phase 2 Schedule Margin Study



# NRO Cost and Acquisition Assessment Group (CAAG) provides data, tools and methods to improve acquisition outcomes for innovative overhead intelligence systems





# Research Initiatives to improve Schedule Analyses

Area	Data Source	Impact	Status
<p>Duration Uncertainty Parameters</p> <p>1</p>	IMS repository and completed activities (actuals) from in-work schedules	Inputs to Schedule Risk Assessments that reflect actual performance	<ul style="list-style-type: none"> <li>Completed industry partner survey for methods and tools</li> <li>Historical performance Calibrator Tool complete</li> <li>Best practice inputs provided to NDIA for PASEG update</li> <li>Reaching out to industry partners to address data driven methods for SRA inputs</li> </ul>
<p>Schedule Benchmarking and Milestone Phasing</p> <p>2</p>	Historical database of major milestones for space programs	Parametric assessment of development schedules and milestone dates to ensure realism for mission achievability	<ul style="list-style-type: none"> <li>Parametric equations for the Schedule Estimate Relation (SER) built into Excel tool and template complete</li> <li>Integrated into the Schedule Risk Analysis (SRA) process as a validation tool</li> <li>Investigating artificial intelligence methods for improving fidelity of results</li> </ul>
<p>Schedule Execution Metric Thresholds</p> <p>3</p>	Schedule Execution Metrics for Historic programs and acquisition outcomes	Predictive Schedule Execution Metrics to ensure schedule realism to achieve mission objectives	<ul style="list-style-type: none"> <li>Study using data science methods and predictive indicators is complete</li> <li>Actively promoting SEM Methods in IPM COTS Analysis tool updates</li> <li>Advancing new phases of the study</li> </ul>
<p>Schedule Margin Sufficiency</p> <p>4</p>	Calculation of Effective Schedule Margin on Historic Program Schedules	Analysis of program's ability to recover from schedule variance, versus likelihood to delay major milestone	<ul style="list-style-type: none"> <li>Phase I Study complete</li> <li>Phase II Study initiated</li> </ul>



1

# Duration Uncertainty Parameters

## Business Need

SRA's can provide a forecast of key event completions and deliveries if the inputs are valid. Many SRA factors used for best case and worst cast durations are subjectively generated. If the SRA input factors do not realistically reflect historical and program performance, the result may be under estimated.

## Data sources

- CAAG survey to Industry on SRA factors and tools
- Repository of completed and in-progress schedules

## NRO Method

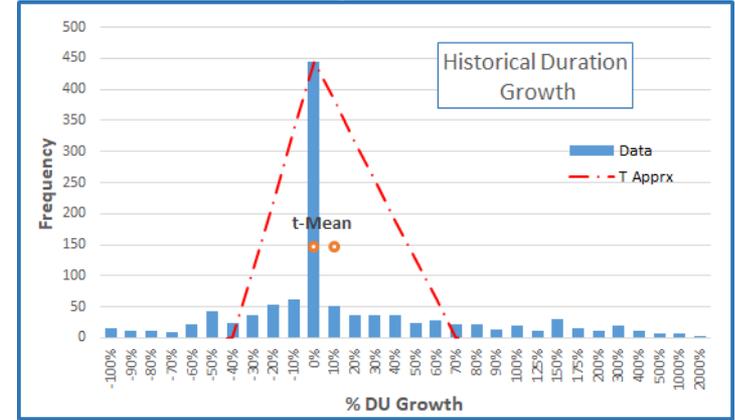
- Historical Performance Calibrator (HPC) tool – Statistically analyze IMS actual durations to curve fit data to a triangle probability distribution curve

## Application at NRO

- Data driven uncertainty factors derive SRA input factors to support knowledge-based decisions to better understand the entire range of possible schedule outcomes

Don't forget to include risk and opportunity register impacts in your SRA

Historical Duration Growth Mapped to Triangle Function



t-DIST Factor Summary						
All	-40%	0%	70%	10%	14%	0.0
Category	BC	ML	WC	Mean	t	Err (Sigma)
Low	-10%	0%	15%	2%	1%	0.0
Med	-25%	0%	50%	8%	6%	0.0
High	-50%	0%	100%	17%	6%	0.1



# 1 IMS Data Mining to Derive SRA Factors

Complete or Partial Complete IMS

1 An IMS repository is a good source of historical data

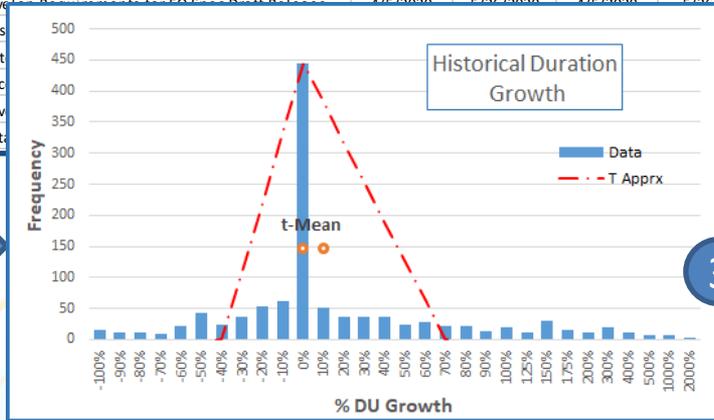
The tool indicates if sufficient data is available to provide reasonable results (see Err Sigma)

Duration growth statistics are calculated for the imported data

Historical Data Import		Status:	11/22/2021	Variance:					107%		
Milestones and summaries not included				Average:				11.4%	28%		
1139	completed tasks			Average:	28.8	25.8	3.0				
Category	UID	Task Name	Start	Finish	B_Start	B_Finish	DU	BDU	Delta	%Delta	
Low	217	Kick off planning	3/3/2020	3/9/2020	3/3/2020	3/9/2020	4	4	0	0%	
Low	150	Generate Key Requirement Fly Sheets	3/10/2020	4/4/2020	3/10/2020	4/4/2020	17	17	0	0%	
Low	435	Develop Requirements for EO Capabilities	4/5/2020	5/25/2020	4/5/2020	5/25/2020	36	36	0	0%	
Low	436	Bras					2020	25	25	0	0%
Med	2552	Fact					2021	8	5	3	60%
Low	1547	Proc					2021	8	5	3	60%
Low	3529	Mov					2021	1	2	-1	-50%
Med	2560	Inst					2021	1	2	-1	-50%

Query "best fit" triangle uncertainty factors by category\*

t-DIST Factor Summary						
All	-40%	0%	70%	10%	14%	0.0
Category	BC	ML	WC	Mean	t	Err (Sigma)
Low	-10%	0%	15%	2%	1%	0.0
Med	-25%	0%	50%	8%	6%	0.0
High	-50%	0%	100%	17%	6%	0.1



3 Stats are binned by category

\* Uses the mean value as the Most Likely Estimator (MLE) for triangle curve fit



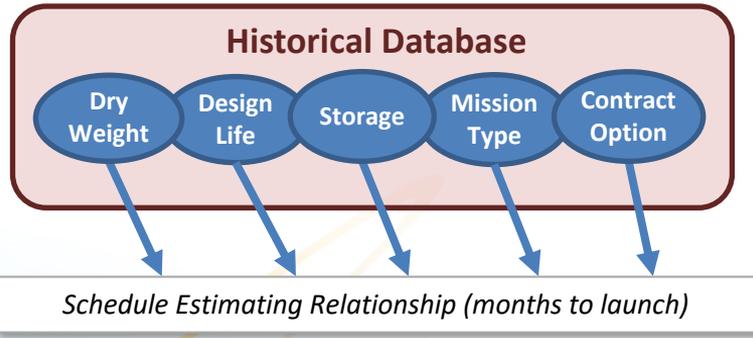
# 2 Benchmarking with a Schedule Estimating Relationship (SER)

### Business Need:

SRA results can be compared to historical data and validate a contractors "bottoms-up" schedule which **ensures schedule realism for the acquisition outcome**. This can provide insight to achievability of a proposed schedule, or the remaining time to complete an in-progress project.

### Data Sources:

- Historical database of satellite development milestones with satellite parameters



### NRO Method/Model/Tool

- Excel template that calculates parametric SER and ratios time to each key milestone in the satellite development

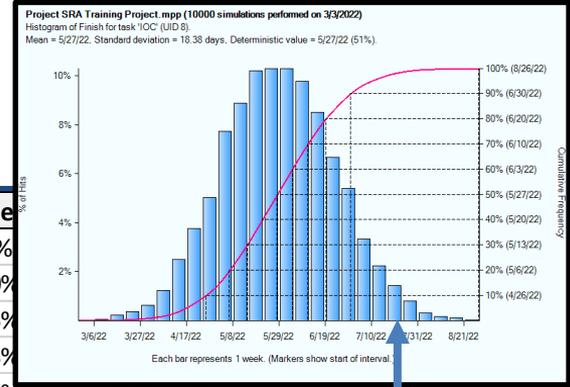
### Application at NRO

- Improve schedule risk analysis with schedule benchmarking
- Can be used for new schedules or in-progress projects
- Investigating AI methods to improve accuracy

### Milestone Phasing

	Type 1	Type 2	Type 3
ATP	0%	0%	0%
PDR	15%	15%	20%
CDR	29%	33%	35%
SV TRR	71%	60%	63%
PSR	98%	95%	95%
Launch	100%	100%	100%

### SRA



This example shows an optimistic SRA date compared to historical data



3

# Schedule Execution Metric (SEM) Thresholds

**Business Need:** Insight into schedule performance and predictive indicators of imminent milestone delay

**Data sources**

- Schedule data in the IPM Central Repository
- Context about acquisition outcome

**NRO Method/Model/Tool**

- SEM Tool (Excel/Visual Basic)
- 2021 SEM Thresholds Study

**Application at NRO**

- Program Office Monthly program reviews with trend analysis to visualize the change in schedule execution over time and increase accountability for reliable forecasting
- Independent schedule analysis for leading indicators of milestone delay, early warning of program reset, or evidence of schedule recovery

## SEM Thresholds Card

Performance Indicator	Condition	Metric	Threshold	Indicator
	On Plan	6-month moving average Baseline Realism Index (BRI) AND 6-month moving average 30-day workoff	≥ 0.65 AND <0.32	Favorable
	Smooth Sailing	6-month moving average Forecast Realism Index (FRI)	≥ 0.67	Favorable
	Monitor Closely	6-month moving average BRI	≤ 0.65	Consuming cost and schedule margin
		6-month moving average BRI (little to no cost or schedule margin)	≤ 0.45	Unfavorable
		6-month moving average BRI (cost and schedule margin available)	≤ 0.20	Unfavorable
		To Complete Baseline Execution Index (TC-BEI)	> 1.10	Optimistic Forecast
	Behind and trending worse	6-month BRI Trend AND 6-month moving average BRI	≤ -0.05 AND <0.80	Unfavorable
	Way off plan	6-month moving average BRI OR 6-month moving average Baseline Progress Index	≤ 0.20 OR ≤ 0.35	Unfavorable
	Overwhelmed by late tasks	6-month moving average 30-day workoff	≥ 0.80	Unfavorable
	Forecast does not reflect past performance	Delta [Baseline Execution Index (BEI) minus TC-BEI]	< -0.05	Unfavorable

**Metric:** defined quantifiable performance measure used to track, monitor and assess schedule execution  
**Threshold:** metric value cutoffs established to determine relative performance, used to understand the meaning of a metric  
**Indicator:** interpretation of the metric based on performance against thresholds

- Favorable:** not likely to experience major milestone delay or program restructure in next 6-12 months
- Unfavorable:** likely to experience major milestone delay or program restructure in next 6-12 months





# 4

## Schedule Margin NRO Phase 1 Study

Business Need: Understanding IMS schedule margin position provides insight into the schedule’s ability to mitigate critical path impacts and deliver on time

### Data sources

- Schedule data in the IPM Central Repository

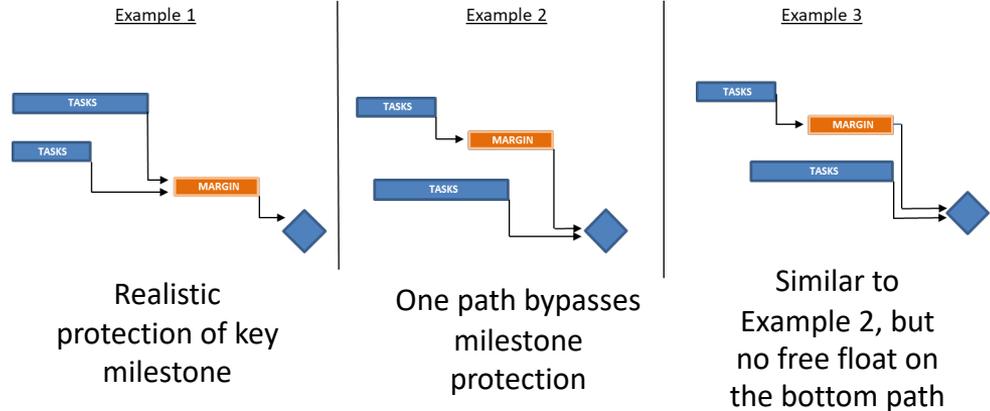
### NRO Method/Model/Tool

- Phase 1 Margin Study quantified effective schedule margin in program schedules at major milestones

### Application at NRO

- Improve practices to better model and manage schedule margin
- Comparison point for schedule analysis for Integrated Baseline Reviews
- Provides framework for assessing schedule margin when performing independent schedule analysis supporting program milestones

The purpose of these examples is to show if the milestone is truly protected by the schedule margin task

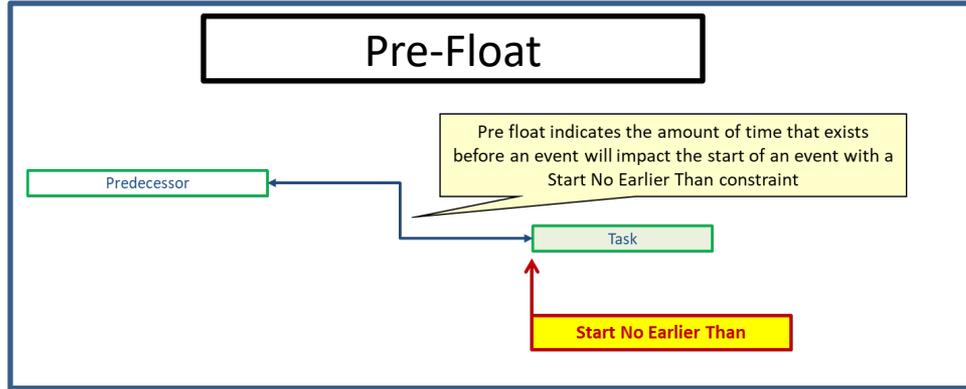


If tasks bypass schedule margin (examples 2 and 3), Effective Schedule Margin is reduced; Schedule Margin Phase 1 study found less than expected schedule margin



# 4

## Phase 2 Schedule Margin Study Objectives



### Areas of Further Study

- Develop a more expansive measure of the ability of the schedule to absorb schedule variance without impact to major milestones
  - Consider pre-float
- Assess the length of schedule and initial margin with acquisition outcomes to work towards understanding adequacy of schedule margin



---

QUESTIONS???



# Presenter Contact Information

---

- Ivan Bembers, [bembersi@nro.mil](mailto:bembersi@nro.mil)
- Siemone Cerase, [cerasesi@nro.mil](mailto:cerasesi@nro.mil)
- Tony Claridge, [claridga@nro.mil](mailto:claridga@nro.mil)
- Michelle Jones, [jonmiche@nro.mil](mailto:jonmiche@nro.mil)

Tools available upon request:

- Schedule Execution Metrics
- Historical performance Calibrator Tool